State of Washington
ARTHUR B. LANGLIE, Governor

Department of Conservation and Development
W. A. GALBRAITH, Director

DIVISION OF MINES AND GEOLOGY
SHELDON L. GLOVER, Supervisor

Bulletin No. 37

INVENTORY OF WASHINGTON MINERALS

PART II

METALLIC MINERALS

By
MARSHALL T. HUNTTING

Volume 1 - TEXT
Volume 2 - MAPS

STATE PRINTING PLANT, OLYMPIA, WASHINGTON
1956

**For sale by Department of Conservation and Development, Olympia, Washington.
Part II price per set (2 volumes—text and maps) $4.50.**

INVENTORY OF WASHINGTON MINERALS

PART II

METALLIC MINERALS

Volume 1 -- TEXT

FOREWORD

Knowledge of the occurrence of minerals in Washington has been accumulating steadily since 1853, when the first mine (a coal property) was developed. Actually it antedates this, for the discovery of a coal outcrop was recorded as early as 1833, though 20 years elapsed before any particular attention was paid to mineral resources, and it was not until about 1860 that State-wide prospecting, at first for gold, was well underway. The early published references to mineral discoveries are, in general, vague and chiefly of historical value, but some are useful in describing deposits that have been forgotten or lost during the passage of years.

In 1890 the office of State Geologist was created by the State Legislature, resulting in the first coordinated effort to catalogue our mineral resources and possibilities. This work was discontinued after two years, but was resumed in 1901 through the establishment of the Washington Geological Survey and has been continuous since then.

During the 90 years or more that prospecting and mining have been active, a vast amount of information has been obtained on the minerals of the state. The literature on the subject is voluminous. The U. S. Geological Survey, U. S. Bureau of Mines, and many other agencies, as well as institutions, organizations, and individuals, have contributed extensively to the fund of published data. Also, mining journals and periodicals, many of which are no longer published, have carried useful accounts of old operations and mineral discoveries.

More than 100 bulletins and reports on geology and mineral resources have been published by the Division of Mines and Geology and its predecessor agencies. Additional material available to the Division has been unpublished, existing as personal observations of staff members and, particularly, as notes from many years of field investigations. All these sources of information can be consulted—and commonly are—when given resources are considered, but searching the literature is a time-consuming task.

To make desired data on industrial minerals and operations more readily available for Divisional use, a card catalogue of all known nonmetallic-mineral references was compiled many years ago by the writer. It gave only brief details of individual deposits, but these, with their citations to further information, became of inestimable value. An immediate use was in the preparation of Bulletin 33, "Nonmetallic Mineral Resources of Washington," published in 1936. Since then the catalogue has been steadily added to by staff members as new information has been obtained, and a similar card file was started for metallic minerals and their operations. This last has been a laborious undertaking, for which Everett P. Hougland, formerly of the Divisional staff, was originally responsible. Later, it was materially added to by Grant M. Valentine, also a former member of the Divisional staff, and was greatly expanded and organized into usable form by Marshall T. Huntting.

The present "Inventory of Washington Minerals" is the result of a considered conviction that the data in these card catalogues would be as useful to the mining industry as they have proved to be to the Division of Mines and Geology and should, therefore, be made available to all who are, or may become, interested in Washington's mineral resources. The listings are purposely made as concise as possible, yet giving certain essential facts. They may be used in obtaining brief general information about any mineral resource, or they may be used as a starting point for detailed investigations. Upon completion of the section dealing with nonmetallic minerals it was considered desirable to publish that material without delay as Part I of the "Inventory." The first printing was in 1949, Grant M. Valentine being in charge of the compilation.

Immediately thereafter work was begun on Part II, which deals with metallic mineral occurrences. This has proved to be a far more elaborate and lengthy project than was foreseen. However, it is believed that the time and expense involved are justified and that the mining industry will find that having this material readily available for reference will fill a real need.

SHELDON L. GLOVER, Supervisor
Division of Mines and Geology

October 10, 1956

CONTENTS

ILLUSTRATIONS

In volume 2

INVENTORY OF WASHINGTON MINERALS

PART II—METALLIC MINERALS

By MARSHALL T. HUNTTING

INTRODUCTION

PURPOSE OF THE REPORT

The primary purpose of this report is to present a brief annotated list of all the metallic mineral occurrences in Washington known to the Division of Mines and Geology. The desirability of making available to the public a large amount of unpublished data in the Division files has long been recognized, and this report includes all this previously unpublished information as well as a summary of all the available published data on metallic mineral occurrences in the state. Through the use of maps it is possible to show the distribution of the various minerals, and in the text the individual deposits are briefly described and also referenced—thus providing the reader with a convenient foundation for a more comprehensive study of any metal in its various mineral forms or of any specific mine or prospect in the state.

An effort has been made to include in this inventory all the metallic mineral occurrences known in the state, even though many of the deposits are obviously of negligible value. This has been done because in the past many mineral occurrences which have been considered to have no importance have, for one reason or another, later proven to be of considerable value. This is a situation which, because of increasing demand for metals, new technological developments, and improved ore-finding techniques, may be expected to develop even more frequently in the future.

The title of this report is actually somewhat a misnomer, as this is really an inventory of the occurrences of the various metals in their mineral forms rather than of the minerals themselves. This may appear to be splitting hairs, but the point is, by using this report a person may look up all known occurrences of copper in Washington but he could not readily find all the occurrences of any given copper mineral.

ACKNOWLEDGMENTS AND SOURCES OF INFORMATION

This report is strictly a compilation, although many of the data included have never been previously published. Some of the most important sources of data used for this inventory are the published reports of various private, State, and Federal agencies. Another valuable source is the large mining-properties card file of the Division of Mines and Geology and its three predecessor organizations, the Washington Geological Survey, the Division of Geology, and the Division of Mines and Mining. Perhaps the largest contribution from these files is material accumulated over a long period of years from all the available mining and geology periodicals. Other sources are the many volumes of unpublished Division field notes, the files of other State agencies, questionnaires, and unpublished private reports.

The writer was fortunate in being allowed to include much nonrestricted material from the files of the U. S. Geological Survey and the U. S. Bureau of Mines. Unavoidably, the extent of this assistance is not fully acknowledged by the individual property references, but the contribution comprises a large amount of accurate up-to-date information about many of the best described properties. These valuable sources of information were generously made available by Mr. M. E. Volin, formerly Chief of the Mining Division, Region II, U. S. Bureau of Mines, and by Mr. A. E. Weissenborn, Regional Geologist of the Spokane office of the U. S. Geological Survey. The assistance of Mr. Henry Hoard, mining deputy in the Whatcom County Assessor's office, in furnishing information on many Whatcom County properties is gratefully acknowledged.

General data on the properties, uses, production, prices, ore minerals, and geology of the various metals were abstracted from numerous standard texts on chemistry and economic geology, from Information Circulars and Minerals Yearbooks of the U. S. Bureau of Mines, Mineral Resources of the U. S. Geological Survey, the Engineering and Mining Journal Metal and Mineral Markets, and, for some metals, from books dealing specifically with those metals. These various sources were not always in agreement in many particulars, and in such instances the most recent or what was believed to be the most reliable data were used.

To Mr. Grant M. Valentine, now District Geologist for the Shell Oil Co. and formerly on the Division staff, credit is due for the organization and a large part of the compilation of this report. His contribution to this inventory is at least as great as that of the writer, but since he had no hand in the final stages of its preparation, the writer accepts all responsibility for any shortcomings that may be noted, and at the same time gives credit to Mr. Valentine for his tedious months of compilation. To Mr. Sheldon L. Glover, Supervisor of the Division of Mines and Geology, the writer is grateful for aid in the preparation of the report.

PLAN OF THE REPORT

As in Part I of the Inventory of Washington Minerals, the data in Part II are presented in two forms—maps and text. Here in Part II, however, the maps and the text are bound in two separate volumes, so that descriptive material and corresponding map may be studied together with the least possible inconvenience to the reader.

In the text (Volume 1) the metals are arranged alphabetically; under each metal the occurrences are grouped by counties which are arranged alphabetically; and under each county they are arranged similarly by property name. Properties about which some information is known but in which the kind of ore is not known are grouped under

a separate heading following the metals. At the end of Volume 1 is a property index in which all properties are listed alphabetically.

The maps (Volume 2) are likewise arranged alphabetically by metals, with a separate map at the end for properties whose ores are not known. However, since some metals are found in only a few known occurrences in this state, some of the maps are combined to show the occurrences of several metals, thus putting some of the metals slightly out of place alphabetically in the map sequence. For example, one map shows occurrences of bismuth, cadmium, cerium, columbium, and tantalum—the latter two being mapped together because of their very close chemical relationship and their close association in nature. Bismuth, cadmium, and cerium are shown on the same map merely for printing economy. Cobalt and nickel are shown on a single map also because of their close chemical alliance and physical association. Printing economy dictated the combining of platinum, selenium, tellurium, and thorium on one map; tin and titanium on another; and uranium, vanadium, and zirconium on another. On the other hand, lode gold and placer gold deposits are described in separate sections in the text and are shown on separate maps to better differentiate the two types of deposits.

Most metallic-mineral properties have more than one metal in their ores, and as this inventory lists all known occurrences of all the metallics in the state, the names of most of the properties appear under several headings in the report, and the properties are shown on several maps. However, each property is described in only one place—under the heading which represents what is believed to be the most important constituent of the ore. For example, the Holden mine in Chelan County is described under copper and is shown on the copper map. It is assigned a number (40) which follows the name in the copper section of the text and is adjacent to the symbol for the mine on the copper map. (On the copper map all properties which are described under the heading "Copper" in the text are shown by a cross "+", and all properties which have some copper, but in which other metals account for the principal values, are shown by a large dot "•". Most of the other maps use these symbols with the same meanings.) However, the Holden mine also produces zinc, gold, and silver, so it is shown on each of these maps, and the name appears in its proper alphabetical position under each of these headings in the text, but following the name in each of these sections is simply a notation "(see under copper)". The number (51) assigned to the Holden mine on the gold map and in the text under gold is not the same as that given the same property under any of the other headings where it may be found, but the number given each property on any given map is the same as the number given the same property in the corresponding section in the text.

Some of the occurrences described in the text do not have a map number and are not shown on any map, because their locations are too inexactly known.

To facilitate following a numbered symbol on a map (in Volume 2) to the description (in Volume 1) of the property represented by the symbol, a finding list (numerically arranged) relating number to property name is on the page facing each map.

The scale of the state maps is such that they can be regarded as index maps only. Locations of the properties are given as precisely as possible in the text, but because of the small map scale, the detail is not as great as it would be on larger scale maps. In order to show the location of all the occurrences in some areas it is necessary to allow a single symbol to represent several closely spaced properties. Even this device leaves some of the small-scale state maps so cluttered with symbols in some areas that there is insufficient room for the identifying numbers. Where this is true, special larger scale county maps are used. These are the maps for copper, gold, lead, silver, and zinc for Stevens County, and for lead and zinc for Pend Oreille County.

Property Descriptions

This inventory is of course subject to the limitations and shortcomings that are inherent in any compilation of this sort in which use is made of a wide variety of sources of information. The critical reader will probably find inaccuracies; many mines and prospects are inadequately described; and others are perhaps described more than adequately—that is, they may be presented in a more favorable light than their merits justify. Very determined effort has been made to avoid these shortcomings, to eliminate duplications, and to make the data as complete and up to date as possible. The only way many of the remaining errors can be corrected is through the active cooperation of the readers. Your corrections and additions are earnestly solicited.

The reader will note that the placer properties are nearly all very inadequately described. This results from the fact that very little has been written about the placers in Washington, which in turn reflects the comparative unimportance of the state's placers. Many of the placer properties had suspended operations before their existence became generally known.

For the reader's convenience the occurrences are described under a standardized set of 14 headings: **Loc** (location), **Elev** (elevation), **Access, Prop** (property), **Owner, Ore, Ore min** (ore minerals), **Gangue, Deposit, Dev** (development), **Improv** (improvements), **Assays, Prod** (production), and **Ref** (references). A date in parentheses following any information in the descriptions indicates the date at which that information is assumed to be correct.

Under **Loc** (location) the position of the deposit is designated, wherever possible, by legal land description, and usually by some supplemental information which relates the location to some geographic feature, and further, the so-called "mining district" is usually given. The legal description is abbreviated; thus, sec. 3, (40-25E) indicates section 3, Township 40 North, Range 25 East, Willamette meridian.

Under **Elev** (elevation) is the altitude in feet above sea level, and in some instances the distance above local valley level is also given.

Under **Access** the distances by trail, road, boat, or railroad to points of principal interest are given.

Under **Prop** (property) the size of the property and the manner in which it is held are indicated. Where the occurrences are covered by mineral claims, the number of claims, type of claims (patented or possessory title), and in many instances the names of the claims are given. Since these features of a mining property are subject to frequent change, the information under this heading cannot be expected to be entirely up to date. Although the amount of property included under one ownership may be of considerable importance, that, of course, is not necessarily a measure of the size and value of the included mineral deposit.

Under **Owner** all the known owners are listed, the present or latest owner first, the earliest owner next, and subsequent owners following in chronological order. The period of ownership or control is indicated by dates in parentheses. The address of the latest owner or lessee is usually given. The names appearing in this section may be those of actual owners or they may be of holders of possessory title, of lessees, or of purchasers on contract. In most instances no attempt was made to indicate the nature of control. Information as to ownership usually can be obtained from the County Auditor of the county in which the property is located. Information on the corporate organization of any mining company doing business in Washington may be obtained from the Corporation Division of the Secretary of State's office in Olympia, and more detailed information on the corporate history of any company which is licensed to sell stock in the state may be obtained from the Securities Division of the State License Department.

Under **Ore,** what is thought to be the most important ore metal is listed first, but for the most part little attempt is made to list the other ores in their exact relative order of importance, although the least important metals ordinarily are last. Some of the metals listed under this heading are not ores in the true sense of the word, but they are included in order to show their presence, even though they have not been recovered and sold. To restrict the metals under this heading to those strictly meeting the qualifications of ore would be impossible in view of the definition: Ore is a mineral or mineral aggregate which contains precious or useful metals and which occurs in such quantity, grade, and chemical composition as to make extraction commercially profitable. The definition thus includes economic factors, such as market prices of the metals, cost of mining, concentration, and transportation, which may change rapidly—rendering today's ore tomorrow's waste, or vice versa.

Under **Ore min** (ore minerals) are all or most of the metallic minerals which have been identified at each deposit, not necessarily in order of abundance or importance. Many of the minerals listed are accessory minerals or even impurities rather than true ore minerals.

Under **Gangue** the ore host mineral is stated, except where this information would duplicate that in the description of the deposit which follows it. Gangue has been defined as the nonmetalliferous or nonvaluable metalliferous minerals in ore, but in this report gangue has been restricted to the nonmetalliferous minerals, and the nonvaluable metalliferous minerals are included with the ore minerals.

Under **Deposit** is a brief description of the occurrence, giving, where possible, the type of mineralization, the country rock, and size and shape of the deposit.

Under **Dev** (development) is a description of the underground workings, surface trenching, and test drill holes. Caved or flooded workings are so designated where known.

Under **Improv** (improvements) are listed those features which fall within the meaning as used in mining law—an artificial change of the physical condition of the earth upon or near a mining claim to facilitate discovery or extraction of minerals. Thus, camp buildings, roads, ore bins, mills, and the like are included under this heading.

Under **Assays** the grade of the ore is indicated by representative assays where available, and preferably by smelter returns on shipments. Assay reports, of course, are extremely subject to over-optimism, deliberate misrepresentation, careless sampling, and honest error. Owing to the none-too-reliable character of some of the source material used, the Division cannot vouch for the accuracy of the reported assays. Thus, the reader should exercise as much caution in his use of the assays reported here as he would in the use of assays from any source of unknown reliability.

Under **Prod** (production) is the date and amount of ore produced. Where the date but not the amount of production is known, only the date is given.

Under **Ref** (references) is a list of abbreviated citations to the published and unpublished reports from which the data for each property were abstracted. The reference is made by a number in bold-face type which refers to a title under the same number in the bibliography on pages 395 to 398. This is followed by the page reference or, in the case of a periodical, by a date (written 7/5/34 [July 5, 1934], or 7/34 [July 1934], or simply 1934) and then the page reference. Where the citation includes several issues of a periodical, the parts of the citation are separated by semicolons. Thus, **1,** 4/18, p. 19; 7/18, pp. 45-46, refers to the Alaska and Northwest Mining Journal for April 1918, page 19, and August 1918, pages 45 to 46. References to individual titles in the bibliography are separated by periods. Certain references are omitted where a given property is listed year after year in annual directories such as the Division of Mines and Geology Directory of Washington Mining Operations or The Mines Handbook. In some instances only the latest entry is listed, and the reader may gain further information about a property by consulting earlier issues of the same annual directory.

Anyone wishing further details about a given property should refer to the specific reports cited under this heading. Most of these reports are available at public and institutional libraries. The only cited publications that are available from the Division of Mines and Geology are those, still in print, that were published by the Division or its predecessor agencies, the Washington Geological Survey, the Division of Geology, and the Division of Mines and Mining.

Abbreviations

Ag—silver
Al—aluminum
approx.—approximately
As—arsenic
Au—gold
av.—average, averaged, averaging
Ave.—avenue
B—boron
Ba—barium
Be—beryllium
Bi—bismuth
Br—bromine
Bros.—Brothers
Bur.—Bureau
C.—Centigrade
Ca—calcium
Cb—columbium
Cd—cadmium
Ce—cerium
Cl—chlorine
Co—cobalt
Co.—Company
conc.—concentrate, concentrates
cor.—corner
Corp.—Corporation
Cr—chromium
Cr.—Creek
Cu—copper
cu.—cubic
Dept.—Department
Dev—development
dia.—diameter
dist.—district
Div.—Division
E.—east
Elev—elevation
est.—estimated
et al.—et alii (and others)
Ext.—Extension
F.—Fahrenheit
Fe—iron
Fk.—Fork
Fr.—Fraction
ft.—foot, feet
Ga—gallium
Ge—germanium
gm.—gram, grams
H—hydrogen
Hg—mercury
Improv—improvements
in.—inch, inches
Inc.—Incorporated
insol.—insoluble
Ir—iridium
Is.—Island
K—potassium
lb.—pound, pounds
Li—lithium
Lk., lk.—Lake, lake
Loc—location
Ltd.—Limited
max.—maximum
Mg—magnesium
mi.—mile, miles
min.—minimum
Mn—manganese
Mo—molybdenum
Mt.—Mount
Mtn., Mtns.—Mountain, Mountains
N.—north
Na—sodium
NE.—northeast
Ni—nickel
no.—number
Nos.—Numbers
NW.—northwest
O—oxygen
Ore min—ore mineral(s)
oz.—ounce, ounces
P—phosphorus
p.—page
Pb—lead
%—percent
pp.—pages
Prod—production
Prop—property
Pt—platinum
R.—river, range
Ref—references
Ry.—Railway
S—sulfur
S.—south
Sb—antimony
Se—selenium
SE.—southeast
sec.—section
Si—silicon
Sn—tin
sq.—square
Sr—strontium
SW.—southwest
T.—township
Ta—tantalum
Te—tellurium
Th—thorium
Ti—titanium
tr.—trace
U—uranium
U. S.—United States
V—vanadium
vol.—volume
W—tungsten
W.—west
Wash.—Washington
yd.—yard, yards
yr.—year, years
Zn—zinc
Zr—zirconium

THE METALS

GENERAL STATEMENT

The chemical elements may be divided into two groups, the metals and nonmetals. The two groups cannot be very sharply defined, and intermediate between them are a number of elements sometimes referred to as semi-metals. Some of the semi-metals, such as arsenic, antimony, and bismuth, are more commonly thought of as metals than are some of the true metals.

The metals constitute over three-fourths of the recognized elements. They possess to a greater or less degree the physical properties of ductility, malleability, opacity to light, metallic luster, and conductivity for heat and electricity. Most metals are comparatively heavy. All except mercury are solid at ordinary room temperatures, and when solid they are crystalline in structure. (On warm days cesium and gallium, which have melting points of 83.3° F. and 85.6° F. respectively, are liquid also.) Further, their chemical properties are such that they commonly play the part of the positive or basic element in a simple compound.

The nonmetals include the gases and some solids. The solid nonmetals, as contrasted with the metals, are brittle, poor conductors for heat and electricity, and are often nonopaque. Chemically, they are usually the acid or negative elements in simple compounds.

The semi-metals are less perfectly metallic in their physical properties and, chemically, they often play the part of the acidic or negative elements in their compounds.

The physical and chemical properties of the metals are manifestations of more fundamental properties in the field of crystal chemistry. These properties—the arrangement or structure, spacing, and type of bond between the atoms—have been made the basis for still other definitions for metals, but unfortunately, as one might guess from the variety of physical properties, the elements show a great diversity of crystal chemical properties also, with continuous and gradual transition from metallic to nonmetallic atomic structures. Thus, even definitions based on the most fundamental known properties of the elements fail to sharply differentiate between metals and nonmetals.

A complicating factor is the dual role that many minerals play. For example, magnesite is an ore mineral of the metal magnesium, and as such might be classed as a metallic mineral; but on the other hand, magnesite is also used in making refractories, and for this use it would be classed as a nonmetallic mineral. Likewise, hematite and limonite, ores of iron, are also used as paint pigments; rutile, a titanium ore mineral, is used in making white pigments; chromite, the source of chromium, is also used as a refractory; and many other minerals can be classed either as metallic or nonmetallic, depending upon the particular use to which they are put. From a strictly practical point of view, the terms "metal" and "metallic mineral" as commonly used are purely conventional expressions.

Here, in Part II (Metallic Minerals) of this report, the occurrences of the following metals and semi-metals are listed: antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, columbium, copper, gallium, germanium, gold, iron, lead, manganese, mercury, molybdenum, nickel, platinum, selenium, silver, tantalum, tellurium, thorium, tin, titanium, tungsten, uranium, vanadium, zinc, and zirconium. The occurrences of several other metals have previously been listed in Part I (Nonmetallic Minerals) of this report. These are the metals whose ore minerals can be classified either as metallic or nonmetallic. They include aluminum, barium, beryllium, boron, calcium, lithium, magnesium, potassium, silicon, sodium, and strontium.

Other minor metals probably will be found in the state as the demand for them increases. Most of the as yet undiscovered minor metals occur as accessory minerals or more often as "impurities" in other common minerals. As such they are difficult to recognize by means other than chemical or spectrographic analysis. Spectrographic analyses, especially, can be expected in the future to disclose more of the rare metals.

PHYSICAL PROPERTIES OF THE METALS

Metal	Chemical symbol	Atomic number	Atomic weight	Specific gravity	Weight per cubic foot (pounds)	Melting point (degrees C.)	Boiling point (degrees C.)
Aluminum	Al	13	26.97	2.702	168	659	2057
Antimony	Sb	51	121.76	6.68	417	630	1440
Arsenic	As	33	74.91	5.73	358	817	610
Barium	Ba	56	137.36	3.5	218	710	1500
Beryllium	Be	4	9.01	1.84	112	1284	2970
Bismuth	Bi	83	209.00	9.80	608	271	1477
Boron	B	5	10.82	2.34	144	2100	2550
Cadmium	Cd	48	112.41	8.642	540	321	767
Calcium	Ca	20	40.08	1.55	97	850	1440
Cerium	Ce	58	140.13	6.78	431	793	2417
Chromium	Cr	24	52.01	7.14	443	1550	2822
Cobalt	Co	27	58.94	8.92	555	1493	3550
Columbium	Cb	41	92.91	8.57	524	2415	3300
Copper	Cu	29	63.54	8.96	558	1083	2595
Gallium	Ga	31	69.72	5.97	369	30	1983
Germanium	Ge	32	72.60	5.32	334	958	2700
Gold	Au	79	197.2	19.3	1,206	1063	2966
Iron	Fe	26	55.85	7.87	490	1540	2735
Lead	Pb	82	207.72	11.34	708	327	1717
Lithium	Li	3	6.940	0.534	33	186	1336
Magnesium	Mg	12	24.32	1.74	109	650	1103
Manganese	Mn	25	54.93	7.44	449	1245	2097
Mercury	Hg	80	200.61	13.546	846	—39	357
Molybdenum	Mo	42	95.95	10.2	636	2622	4800
Nickel	Ni	28	58.69	8.9	555	1455	2732
Platinum	Pt	78	195.23	21.45	1,333	1773	4530
Potassium	K	19	39.096	0.86	54	62	760
Selenium	Se	34	78.96	4.81	299	217	423
Silicon	Si	14	28.09	2.32	151	1410	2480
Silver	Ag	47	107.880	10.49	655	960	2212
Sodium	Na	11	22.997	0.97	61	98	883
Strontium	Sr	38	87.63	2.6	158	770	1380
Tantalum	Ta	73	180.88	16.6	1,036	2996	5300
Tellurium	Te	52	127.61	6.24	390	452	1390
Thorium	Th	90	232.12	11.7	705	1842	4500
Tin	Sn	50	118.70	7.28	359	232	2270
Titanium	Ti	22	47.90	4.5	281	1690	3535
Tungsten	W	74	183.92	19.3	1,204	3410	5900
Uranium	U	92	238.07	19.05	1,166	1133	2071
Vanadium	V	23	50.95	6.11	272	1900	3000
Zinc	Zn	30	65.38	7.14	446	419	906
Zirconium	Zr	40	91.22	6.5	399	1830	5000

Distribution by Counties

The following table shows the counties in Washington in which occurrences of the various metals have been reported. Many of these occurrences have not yet been proven to be of commercial grade or quality or may be of academic interest only, but many of the occurrences in these categories may later prove to have commercial value.

	Asotin	Benton	Chelan	Clallam	Clark	Columbia	Cowlitz	Douglas	Ferry	Garfield	Grant	Grays Harbor	Jefferson	King	Kittitas	Lewis	Lincoln	Mason	Okanogan	Pacific	Pend Oreille	Pierce	Skagit	Skamania	Snohomish	Spokane	Stevens	Thurston	Whatcom	Yakima
Antimony			X						X					X	X	X			X		X		X		X		X		X	X
Arsenic			X						X					X	X	X			X		X	X	X	X	X		X		X	X
Bismuth									X					X					X						X		X			
Cadmium									X												X						X			
Cerium								X	X			X		X					X		X									
Chromium			X	X				X	X						X				X				X		X		X		X	
Cobalt			X						X						X	X		X	X		X				X		X			
Columbium																											X			
Copper			X	X	X		X		X				X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X
Gallium			X						X					X							X						X			
Germanium																					X						X			
Gold	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X		X	X
Iron	X		X	X	X		X		X	X		X	X	X	X		X	X	X	X	X		X		X		X	X	X	
Lead			X		X		X		X					X	X	X	X		X	X	X	X	X	X	X	X	X		X	X
Manganese			X	X					X			X	X		X	X		X	X				X		X	X	X		X	X
Mercury			X	X	X		X							X	X	X			X			X	X		X					X
Molybdenum			X						X		X			X		X	X		X		X	X	X	X	X		X		X	X
Nickel			X						X						X	X		X	X		X		X		X		X		X	X
Platinum			X	X	X				X			X			X				X	X			X	X	X					
Selenium									X																					
Silver		X	X	X	X		X		X		X			X	X	X	X	X	X		X	X	X	X	X	X	X		X	X
Tantalum																			X								X			
Tellurium									X										X								X		X	
Thorium								X	X			X		X					X		X									
Tin			X											X							X				X	X	X			
Titanium	X		X	X	X			X	X	X		X		X	X	X			X	X					X	X	X			
Tungsten	X		X						X						X	X			X		X	X			X	X	X			X
Uranium			X						X		X			X	X	X	X		X		X	X			X	X	X			X
Vanadium																								X	X					
Zinc			X	X	X		X		X					X	X	X	X	X	X		X	X	X	X	X		X		X	X
Zirconium	X			X				X	X	X		X								X										

ALUMINUM

Properties—Aluminum is the third most abundant element in the earth's crust, comprising 8 percent of the crust to a depth of 10 miles, exceeded only by oxygen and silicon. It is an essential constituent of nearly all the important rocks except peridotite, sandstone, and limestone, and even in these it is a common impurity. It is easily oxidized, occurring most commonly as oxides and silicates, usually combined with other elements, and, because of its ease of oxidation, special techniques are necessary in smelting its ores. Some of the properties of aluminum are shown in the table on page 12. It is only about one-third as heavy as iron, and many of its uses derive from its light weight, combined with good malleability and resistance to corrosion, its high electrical and thermal conductivity, silvery luster, and high power of reflecting light and heat.

Uses—The largest user of the metal and its alloys is the building trade—for roofing, siding, window frames, ventilating ducts, and many other applications. Other large users are in the field of transportation—for trucks, busses, railroad cars, and of course for airplanes, the latter use being especially great during wartime expansion of the Air Force. Aluminum and its alloys are used in cooking utensils, household appliances, electrical wire and cable, machinery, furniture, tools, instruments, foil, and chemicals.

Production—Production involves reduction of bauxite to alumina (Al_2O_3) by the Bayer process, followed by treatment of the alumina by the Hall process, which produces metallic aluminum by electrolysis in a bath of molten cryolite. The largest production cost is for electricity. Because of the availability here of cheap electrical power a sizable portion of the United States production of aluminum comes from Washington, but as yet none has come from Washington ores. However, exploration of ferruginous bauxite in the southwestern part of the state by the Aluminum Company of America, and of high-alumina clays at several places in the state by Federal agencies has revealed substantial tonnages of these potential ores of aluminum, and it is reasonable to assume that some of them will be used in the not-too-distant future.

In 1955 there were five aluminum reduction plants in Washington, one each at Longview, Spokane, Tacoma, Vancouver, and Wenatchee. The 1953 production from these plants was nearly 50 percent greater than that of the previous year, and in 1954 output increased 8 percent to approximately 430,000 short tons of metal having a value of about $175 million.

Prices—The price history of aluminum is interesting. In 1856 the price was about $90 a pound; at the time of Hall's discovery in 1886 it was about $5; between 1897 and 1924 the price fluctuated violently several times between peaks as high as 61 cents and lows as little as 19 cents; the 1924 price of 25 cents declined steadily to 15 cents by 1941, at which it remained until 1947, when it began a slow rise to 23.2 cents by January 1955. During the past few decades, when aluminum has been produced in important commercial quantities, its market price has been remarkably stable, the fluctuations being relatively small and gradual.

Ore minerals and geology—The principal ore of aluminum is bauxite, which is a mixture of hydrous aluminum oxides ranging from gibbsite, $Al_2O_3 \cdot 3H_2O$ to boehmite and diaspore, both $Al_2O_3 \cdot H_2O$, with corresponding ranges of 65 to 85 percent Al_2O_3. Bauxite belongs to a group of residual materials called laterite, and is produced from aluminum-bearing rocks such as syenite, granite, diorite, basalt, shale, and clay by weathering processes in which hydrated aluminum oxides are concentrated by removal of other constituents. All bauxite contains impurities, including silica, titania, and iron oxides. During World War II plants were built for the production of alumina from high-alumina clays, containing 35 percent or more Al_2O_3; from alunite, $K_2Al_6(OH)_{12}(SO_4)_4$, containing 37 percent Al_2O_3; and from anorthosite, a rock composed largely of feldspar, labradorite or anorthite, the latter having the formula, $CaAl_2Si_2O_8$ and containing 36.7 percent Al_2O_3. Some of these plants produced briefly on an experimental basis, but they were unable to compete successfully with plants using bauxite as ore. None of these materials other than bauxite are usable under present conditions as an ore of aluminum.

Occurrences

Occurrences of the minerals which might under certain conditions be classed as ores of aluminum are described in the previously published Part I (Nonmetallic Minerals) of this report—ferruginous bauxite, high-alumina (refractory) clays, alunite, and feldspar.

ANTIMONY

Properties—Antimony is chemically similar to arsenic and bismuth. The metal is silver white, exceedingly brittle, and has a hardness (Moh's scale) of 3.0 to 3.5. It is a poor conductor of heat and electricity. Other properties are given in the table on page 12. Those properties which have important influence on its uses are: expansion on solidifying from a melt, strong diamagnetism (property of repelling a magnetic field), and marked thermoelectric properties. It crystallizes in the rhombohedral division of the hexagonal system. Antimony commonly shows two valences, 3 and 5. With a valence of 5 it acts as a nonmetal, but in the valence of 3 it plays the part of either a nonmetal or a metal. Thus it falls in the class of semi-metals. It is not acted upon by air at room temperatures, but when heated it burns to form white fumes of the oxide Sb_2O_3.

Uses—About half of the antimony used is in the form of antimonial lead, in which the antimony content varies from about 2 to 25 percent, depending upon the use. Listed in decreasing order of importance from the point of view of tonnage, antimonial lead is used as bearing metal, storage battery plates, type metal, sheet and pipe

for the chemical and building industries, castings, cable covering, collapsible tubes and foil, and ammunition. In wartime the last mentioned use assumes greater importance, of course. Substitutes for antimony have been developed for many of these uses, but not in the manufacture of type metal. In this application its value lies in hardening the type and especially in the unusual property of expanding when it cools. Antimony has some uses as alloys with other metals—tin, copper, zinc, and aluminum being most common. Chemical compounds of antimony are used in greatest quantities in ceramics but are also important as ingredients of paints and lacquers, in flameproofing textiles, in coloring glass, in manufacturing cellulose acetate, and in miscellaneous uses such as vulcanizing rubber, colorfast dyes, and medicinal products.

Production—Antimony was first discovered in Washington probably in 1892 at the Great Republic mine in King County. A little ore was mined there between 1900 and 1905. Other small, sporadic production has been reported from Okanogan and Stevens Counties: an estimated 2,300 tons during World War I; small amounts in 1936, 1937, and 1939; 2 carloads in 1941; 205 tons in 1946; 335 tons in 1947; 48 tons in 1949; an estimated 150 tons in 1951; and an estimated 35 tons were mined and stockpiled in 1952.

Prices—The price of antimony has been very erratic, at times showing wide variations from month to month as well as from year to year. For example, the price of 10 cents per pound in 1915 jumped to 44 cents early in 1916. Later in the same year it dropped to 11 cents, only to rise to 33 cents early in 1917 and then drop back to 14 cents later that year. There were similar fluctuations during the period 1924 to 1927, and in 1952 the price ranged between an all-time high of 53 cents and a low of 38 cents. Four times during the period 1905 to 1935 the price was as low as 8 cents, with intervening highs of 16 cents or more. This chaotic price history has been a large factor in retarding the development of antimony properties in this country.

Ore minerals—The principal ore of antimony is the sulfide, stibnite, Sb_2S_3, containing 71.4 percent antimony, but most of the normal domestic supply is recovered as a byproduct from smelting copper, silver, and lead ores, in which it occurs most commonly as tetrahedrite, $Cu_{12}Sb_4S_{13}$, containing about 25 percent antimony. Native antimony occurs elsewhere, but it is not known in Washington. Three of the four known antimony oxides, valentinite, Sb_2O_3, cervantite, $Sb_3O_6(OH)$, and stibiconite, $Sb_3O_6(OH)$, are found in this state in small quantities, and in some countries these oxides are important ore minerals. Occurrences have been reported in Washington of the following minerals in which antimony is combined with one or more of the elements, lead, silver, copper, arsenic, iron, and sulfur: kermesite, Sb_2S_2O; pyrargyrite, Ag_3SbS_3, containing 59.7 percent silver, 22.5 percent antimony; boulangerite, $Pb_5Sb_4S_{11}$; stephanite, Ag_5SbS_4; jamesonite, $Pb_4FeSb_6S_{14}$; bournonite, $PbCuSbS_3$; geocronite, $Pb_5(Sb,As)_2S_8$; berthierite, $FeSb_2S_4$; bindheimite, $Pb_2Sb_2O_7nH_2O$; dyscrasite, Ag_3Sb; zinkenite, $Pb_6Sb_{14}S_{27}$; andorite, $PbAgSb_3S_6$; meneghinite, $Pb_{13}Sb_7S_{23}$; and diaphorite, $Pb_2Ag_3Sb_3S_8$.

Geology—The antimony-bearing minerals can form under a wide range of conditions and they occur associated with a great variety of minerals, but stibnite, the only important ore of antimony, is found typically in epithermal deposits. As described by Purdy:[1]

> Stibnite in Washington shows no particular affinity to any individual rock type. Commonly, stibnite occurs, (1) as all or part of the cementing material in breccias, (2) as irregular masses erratically distributed in quartz veins, or as disseminated particles or clusters throughout quartz veins, (3) as replacement deposits associated with fractured and/or silicified areas in limestone, and (4) as small lenticular bodies, veins, veinlets, and disseminated particles throughout hydrothermally altered zones, or it is erratically distributed along shears in those zones. In all of these instances the stibnite proves to be the last sulfide mineral to have formed, which attests to the very low temperature and pressure conditions that seem to be most favorable for its development. As is characteristic of the ephithermal group, the stibnite deposits are erratic and unreliable in the extreme, the majority of them the world around only reaching to comparatively shallow depths, possibly not over 2,000 feet, and containing ore of extremely irregular grade along the strike and dip. Most deposits, probably because of erosion since they were formed, seem to die out within a few hundred feet of the surface.

[1] Purdy, C. P., Jr., Antimony occurrences of Washington: Washington Div. Mines and Geol. Bull. 39, pp. 53-54, 1951.

Occurrences

The map showing the numbered antimony occurrences is plate 1, on page 7 in volume 2.

CHELAN COUNTY

Bald Eagle and Gray Eagle
(see under copper)

Blewett
(see Peshastin under gold)

Caledonia (10)
(see under gold)

Ellen
(see Van Epps)

Gray Eagle
(see Bald Eagle and Gray Eagle under copper)

Humbug
(see under lead)

Hunter (4)
(see under silver)

Keefer Brothers (6)
(see under molybdenum)

King Solomon
(see Van Epps)

La Rica
(see Peshastin under gold)

Little Jap (2)
(see under silver)

Marcus Stein (1)
(see under silver)

Orphan Boy (5)
(see under silver)

Peshastin (9)
(see under gold)

Sevenmile Creek (1A)
Loc: SE¼ sec. 15, (31-17E), on Sevenmile Cr. **Elev:** 3,200 ft. **Access:** Road from Lucerne and ½ mi. of trail. **Owner:** Oscar Getty, Lucerne, Wash. (1952——). **Ore:** Antimony. **Ore min:** Stibnite, pyrite, nickel. **Deposit:** 2 veins, one 2 to 5 ft. thick and traceable for 50 ft., the other 10 to 12 ft. thick. Both are silicified breccia zones in granodiorite. They contain pyrite, a very little stibnite, and some green nickel stain. **Dev:** 100-ft. adit on lower (wider) vein. **Ref: 158.**

Silver Fiend (8)
(see under lead)

Snook and Ellen
(see Van Epps)

Sunday Morning (3)
(see under silver)

Van Epps (Snook and Ellen, King Solomon) (7)
Loc: SW¼ sec. 4, (23-15E), at head of Solomon Cr. on W. end of Solomon Mtn. **Elev:** 6,000 ft. **Access:** 12 mi. up Jack Cr. and 3 mi. up Solomon Cr. by trail. **Prop:** 15 unpatented claims. **Owner:** B. F. Harrison, Seattle, Wash. (1949). **Ore:** Antimony, gold, silver, lead, zinc, nickel. **Ore min:** Arsenopyrite, millerite, chalcopyrite, galena, stibnite, berthierite, sphalerite. **Gangue:** Quartz, carbonate minerals. **Deposit:** Mineralized contact zone 10 to 20 ft. wide along contact of diorite and serpentine has been traced for 220 ft. **Dev:** 210-ft. adit, 28-ft. adit, 10-ft. crosscut, open cut. **Assays:** Sample taken across zone at Snook adit assayed 0.22 oz. Au, 0.58 oz. Ag. Assay at Ellen adit gave 0.04 oz. Au, nil Ag. **Ref: 63,** p. 62. **67,** p. 29. **130,** p. 59. **132,** pp. 62-66.

Wenatchee
Loc: Wenatchee dist. **Ore:** Antimony. **Deposit:** Ore from the Antimony Queen mine in Okanogan County was shipped to Pateros and thence to Wenatchee during 1916. Probably this fact is responsible for reported antimony production in the Wenatchee area. **Prod:** Small production reported in 1916. **Ref: 67,** p. 46.

White Star
(see under lead)

CLALLAM COUNTY

Bright Angel (1)
(see under manganese)

FERRY COUNTY

Advance (15)
(see under silver)

Black Hawk (6)
(see under lead)

Colorado (7)
(see under lead)

Comstock (1)
(see under copper)

Gwin (4)
(see under silver)

Hall Creek
(see Gwin under silver)

Juliet (9)
(see under lead)

Keystone (14)
(see under silver)

Kohler (3)
(see under copper)

La Fleur
(see Comstock under copper)

Little Tom
(see Juliet under lead)

Longstreet (16)
(see under silver)

Meteor (12)
(see under silver)

Montana (10)
(see under silver)

New York (13)
(see under lead)

Old Nell (17)
Loc: Near center S½ sec. 36, (32-36E), ¾ mi. NE. of Covada post office. **Prop:** 1 claim. **Ore:** Antimony, silver, gold. **Ore min:** Native antimony. **Deposit:** Quartz veinlets in granodiorite and quartzite. **Dev:** 7-ft. shaft; open cut 8 ft. long, 4 ft. deep; 25-ft. adit. **Assays:** Sample from open cut near center of the claim showed tr. Au, 0.20 oz. Ag. **Ref: 122,** p. 169. **163,** p. 54.

Perry (18)
Loc: Near center NE¼ sec. 36, (32-36E), 1 mi. NE. of Covada post office. **Prop:** 1 claim. **Owner:** Joseph Hartwell (1912). **Ore:** Antimony. **Deposit:** 4-ft. quartz vein in quartzite carries antimony, well mineralized and resembling the Longstreet vein. **Dev:** 42-ft. slope, two 10-ft. adits, several open cuts. **Assays:** Vein is rich in antimony. **Ref: 122,** p. 169. **163,** p. 80.

Pin Money (2)
(see under gold)

Polepick (22)
(see under copper)

Robert E. Lee (19)
Loc: Near center NE¼ sec. 36, (32-36E), Covada dist. **Elev:** 2,160 ft. **Access:** 5 mi. S. of Inchelium by road. **Prop:** 2 unpatented claims. **Owner:** H. B. Rosenbaum, Inchelium, Wash. (1949). **Ore:** Antimony, silver, gold. **Ore min:** Stibnite, pyrite, arsenopyrite, sphalerite, chalcopyrite, tetrahedrite, galena. **Gangue:** Altered granodiorite. **Deposit:** Silicified and altered granodiorite bordering an alaskite dike. Zone on one side is 10 to 15 ft. wide and on the other side, 60 to 70 ft. wide. **Dev:** 76-ft. crosscut in which is a 5-ft. winze, also a glory hole 40 by 100 by 50 ft. deep. **Assays:** One sample showed 57.35% Sb. Assay of a picked sample showed tr. Au, Ag. **Ref: 7,** p. 196. **105,** 1908, p. 686. **122,** pp. 168-169. **129,** p. 58. **132,** pp. 68-71. **141,** p. 50. **163,** pp. 66-67.

Rosario (11)
(see under copper)

Silver Crown No. 1 (21)
Loc: NW¼ sec. 6, (31-37E), just E. of Silver Crown No. 2. Covada dist. **Prop:** 1 claim. **Owner:** Mr. Howe (1912). **Ore:** Antimony. **Ore min:** Pyrite, stibnite (?). **Deposit:** Several quartz veins 4 to 16 in. wide in quartzite. One 16 in. wide consists of solid quartz with some pyrite and antimony. **Dev:** 12-ft. shaft, 125-ft. adit, several open cuts. **Ref: 163,** pp. 58-59.

Silver Leaf (5)
(see under silver)

Stray Dog (8)
(see under silver)

Summit (20)
(see under lead)

KING COUNTY

Aces Up (13)
(see under silver)

Bear Basin (9)
(see under silver)

Cleopatra (10)
(see under silver)

Coney Basin (7)
(see under copper)

Dawson (11)

Loc: NW¼ sec. 24, (25-10E), near head of Bear Cr. **Elev:** 5,350 ft. **Access:** Trail from Cleopatra Basin. **Prop:** Part of 25 claims in the Bear Basin group. **Owner:** Bear Basin Mining Co., Bremerton, Wash. (1949). **Ore:** Antimony. **Ore min:** Pyrite, stibnite, stibiconite. **Gangue:** Altered granodiorite, rhodochrosite. **Deposit:** Altered zone in granodiorite 11 ft. wide is mineralized for 1½ ft. along the hanging wall. Mostly pyrite but some stibnite as radiating clusters of crystals ½ in. in diameter. **Dev:** 2 open cuts. **Ref: 132,** pp. 83-84.

Dutch Miller (15)
(see under copper)

Gold Mountain (2)
(see under silver)

Grand Central (14)

Loc: Sec. 29, (25-11E), S. of Money Cr. **Access:** 1 mi. from railroad at Berlin. **Owner:** Gold Mountain Mining Co. (1915). **Ore:** Antimony, gold. **Ore min:** Stibnite (in upper adit), pyrite. **Gangue:** Quartz, calcite. **Deposit:** Narrow veinlets of quartz, calcite, and pyrite in a 40-ft.-wide zone in Keechelus andesite. **Dev:** An upper adit and a 1,200-ft. lower adit. **Assays:** Av. $4.00 per ton (probably in gold). **Prod:** 1908. **Ref: 97,** 1908, p. 578. **116,** no. 7, 1907, p. 13. **147,** pp. 171, 185.

Great Republic (Happy Thought) (4)

Loc: N½SW¼ sec. 33, (26-11E), at first falls on Happy Thought Cr. **Elev:** 1,200 ft. **Access:** 1½ mi. up Miller R. road, thence by trail. **Prop:** 5 unpatented claims. **Owner:** Charles Wible, Tacoma, Wash. (1949). Great Republic Gold Mining Co. (1902-1905). **Ore:** Antimony, gold, silver. **Ore min:** Stibnite. pyrite. **Gangue:** Quartz, calcite. **Deposit:** Flat-lying mineralized fault in andesite. At one place a lens of stibnite 2½ ft. wide is exposed for a distance of 4 ft. **Dev:** 2 adits connected by a raise total 1,100 ft. of workings. **Assays:** One assay showed 14.05% Sb, 0.03 oz. Au, 2.41 oz. Ag. 6 samples taken to show mineral distribution, not av. grade of ore, showed 0.06% to 21.62% Sb, nil to 0.50 oz. Ag from widths of 0.2 to 4.0 ft. **Prod:** 1938-1941. **Ref: 88,** p. 84. **130,** p. 59. **132,** pp. 75-78. **141,** p. 50. **157. 159,** p. 135.

Happy Thought
(see Great Republic)

Kimball (3)
(see under gold)

Last Chance (6)
(see under gold)

Lennox (8)
(see under gold)

Mohawk (5)

Loc: Sec. 9, (25-11E), Miller R. dist., N. of Seattle Cascade property. **Ore:** Antimony. **Ref: 114,** no. 5, 1909, p. 112.

Pedro
(see under copper)

Salmon Creek (1)

Loc: S½ sec. 10, (26-10E), 1 mi. S. of Baring. **Prop:** 5 unpatented claims. **Owner:** W. R. Anderson, Baring, Wash. (1936). **Ore:** Reportedly antimony. **Ref: 158.**

Silver Star (12)
(see under silver)

Sockless Jerry
(see Last Chance under gold)

KITTITAS COUNTY

Denny
(see Goat Mountain)

Goat Mountain (Denny) (1)

Loc: NE¼ sec. 10, (23-14E), at base of Goat Mtn. about 300 ft. above Cle Elum R. **Elev:** 3,700 ft. **Access:** 1½ mi. above Fortune Cr. on Cle Elum R. road, thence across the river and up a small creek. **Owner:** Fred Denny, Seattle, Wash. **Ore:** Antimony. **Ore min:** Stibnite, pyrite, magnetite, chromite, nickeliferous carbonate. **Gangue:** Quartz, calcite, sericite. **Deposit:** Breccia along the fault contact of Swauk sediments with serpentine contains a 6-in. quartz vein mineralized with stibnite. **Dev:** 178-ft. adit, 3 open cuts. **Assays:** 2 representative samples showed 0.15% and 1.75% Sb. **Ref: 111,** p. 1. **132,** pp. 87-90. **146,** p. 14.

Grizzly Bear
(see under gold)

Majestic
(see under gold)

Ruby King
(see under gold)

LEWIS COUNTY

Jug Lake (2)

Loc: Reportedly on the W. shore of Jug Lk. **Access:** Trail up Summit Cr. or up Deep Cr. from Copper City. **Ore:** Antimony. **Ore min:** Stibnite. **Deposit:** Said to be a 2-ft. vein of antimony sulfide exposed in the lake shore and extending into the lake. **Note:** One investigator was unable to find this prospect. **Ref: 158.**

Reeves (1)

Loc: Center NE¼ sec. 29, (15-11E), ¾ mi. NW. of Frying Pan Lk. **Elev:** 5,300 ft. **Access:** 7 mi. by trail from Ohanapecosh Hot Springs. **Prop:** 1 claim: High Jack No. 2. **Owner:** Abandoned (1949). W. R. Reeves, Universal Alaska Mining Corp. (1933). **Ore:** Antimony. **Ore min:** Stibnite, stibiconite. **Gangue:** Quartz. **Deposit:** A hydrothermally altered zone in serpentine 10 ft. wide contains a 6- to 8-in. band of stibnite-bearing siliceous breccia. **Dev:** Trench and caved adit (1947). **Ref: 132,** p. 91.

OKANOGAN COUNTY

Andy O.
(see Andy O'Neil under silver)

Andy O'Neil (44)
(see under silver)

Antimony
Loc: NW¼ sec. 30, (38-27E). **Ore:** Antimony. **Ore min:** Stibnite. **Deposit:** Country rock is slate and quartzite. No vein observed, but short irregular drifts in the adit probably represent places where the ore was removed. **Dev:** 200-ft. adit. **Ref: 154**, p. 107.

Antimony Bell (Antimony Belle) (37)
Loc: NE¼SE¼ sec. 25, (31-21E), on hill SE. of the S. Fk. of Gold Cr. **Elev:** 2,300 ft. **Access:** 3 mi. by road up the S. Fk. of Gold Cr., thence a few hundred yards by trail. **Prop:** 1 claim: Antimony Bell. **Owner:** Charles Williams, Carlton, Wash. (1949). **Ore:** Antimony. **Ore min:** Stibnite, stibiconite. **Gangue:** Calcite, breccia. **Deposit:** Stibnite occurs along a shear zone in greenstone. The shear zone is 3 to 10 in. wide and has been exposed at intervals for 200 ft. **Dev:** 32-ft. shaft, 25-ft. adit, 20-ft. adit, 25-ft. adit in which is a 20-ft. drift, open cut. **Prod:** 1,300 lb. of stibnite shipped in 1940. **Ref: 132**, pp. 107-109.

Antimony Queen (New Deal, Dixie Queen, Reedy, Silver Seal) (34)
(see also Jumbo)
Loc: SW¼NW¼ sec. 11, (31-21E). **Elev:** 2,050 to 2,550 ft. **Access:** 4.3 mi. up Gold Cr. road from Methow highway. 21 mi. to railroad at Pateros. **Prop:** 4 unpatented claims: Jumbo, Silver Seal Nos. 1 to 3. **Owner:** H. B. Johnston, Seattle, Wash. leasing to G. O. P. Antimony, Inc. (1951-1952). Antimony Queen Mining Co. (1907-1908). H. B. Johnston, Vernon La-Motte, George Gibson (1940). William Oldfield (1941). **Ore:** Antimony, gold, silver, tungsten. **Ore min:** Stibnite, pyrite, scheelite, pyrrhotite, galena, jamesonite, sphalerite, arsenopyrite, chalcopyrite. **Gangue:** Calcite. **Deposit:** Quartz veins and mineralized breccia zones in limy argillite. One vein is 2 to 12 in. wide and carries from 10% to 90% stibnite. Ore shoots up to 2 ft. wide and 40 ft. long. **Dev:** 3 main adits, a caved shorter adit, and several open cuts. Total length of workings about 1,000 ft. **Assays:** A 4-ft. sample from the face on the No. 5 level assayed 0.10 oz. Au, 3.6% Sb, 2.4% As. Another sample showed 0.46 oz. Ag. **Prod:** 1,050 tons of ore from 1907 to 1941. 20 tons produced in 1941 assayed 27% Sb. 1951. **Ref: 37**, pp. 50-51. **43**, 1918, p. 309. **97**, 1918, p. 42. **105**, 1907, pp. 41, 264. **108**, 4/41, p. 12. **130**, p. 58. **132**, pp. 109-122. **133**, p. 33. **141**, p. 51. **157**. **158**.

Apache (48)
(see under silver)

Arizona
(see under silver)

Arlington (28)
(see under silver)

Bales (31)
Loc: SW¼NE¼ sec. 17, (32-22E), 2 mi. NE. of Carlton. **Elev:** 3,200 ft. **Access:** Bulldozer trail. **Prop:** 1 unpatented claim: Bales. **Owner:** Ollie Scott and D. R. Smith (1949——) leasing to Ernest Oberbillig (1951-1952). **Ore:** Antimony. **Ore min:** Stibnite, stibiconite. **Deposit:** Altered and silicified zones up to 7 ft. wide in diorite, greenstone, and argillite contain veins of massive stibnite as much as 2 ft. wide. Stibnite av. 4 in. wide over an exposed length of 240 ft. **Dev:** Surface trenching, 75-ft. crosscut with 120-ft. drift and stope, 110-ft. adit. **Assays:** An assay of vein matter at the discovery post yielded 10.9% Sb. Arsenic av. about 0.2%. **Prod:** 1951-1952 (100 tons ore est). **Ref: 132**, pp. 122-123. **133**, p. 33. **158**.

Bellevue (6)
(see under gold)

Billy Goat (1)
(see under copper)

Buckeye
(see under silver)

Buckeye (8)
(see under copper)

Bunker Hill
(see Silver King under lead)

Carlquist (10)
Loc: SE¼NW¼ sec. 30, (40-29E), ½ mi. E. of Mud Lk., 10 mi. E. of Oroville. **Elev:** 4,000 ft. **Prop:** Deeded land. **Owner:** John Widell (1947). **Ore:** Antimony. **Ore min:** Boulangerite, arsenopyrite. **Deposit:** A 4-in. quartz vein along a fault in quartzite carries scattered ore minerals. **Dev:** Pit 5 ft. square and 4 ft. deep. **Ref: 132**, p. 92.

Castle Creek (39)
(see under lead)

Chief Sunshine (18)
(see under silver)

Chloride
(see under silver)

Coyote (33)
Loc: Center sec. 14, (31-21E), on ridge at junction of the Middle Fk. with Gold Cr. **Elev:** 2,800 ft. **Access:** ½ mi. up the Middle Fk .road, thence by trail for ¼ mi. **Prop:** 1 claim: Coyote. **Owner:** Abandoned (1948). **Ore:** Antimony. **Ore min:** Stibnite, pyrite. **Gangue:** Quartz. **Deposit:** Mineralization along a narrow brecciated zone in argillite. **Ref: 132**, pp. 123-124.

Crystalite
(see under gold)

Dixie Queen
(see Antimony Queen)

Double Header
(see Little Chief under silver)

First Thought (23)
(see under silver)

Fourth of July (29)
(see under silver)

Frankie Boy (21)
(see under silver)

Grand Coulee
(see Little Chief under silver)

Hardscrabble (13)
(see under silver)

Hargrove
(see Silver King under lead)

Healum (36)
Loc: Several hundred yd. S. of Gold Cr., on a small tributary which is about 2 mi. W. of mouth of Gold Cr. **Owner:** Mr. Healum, Methow, Wash. (1940). **Ore:** Antimony. **Deposit:** Small deposit. **Ref: 158**.

Hercules (42)
(see under lead)

Horn Silver (4)
(see under silver)

Ivanhoe (7)
(see under silver)

Jumbo (35)
(see also Antimony Queen)

Loc: SW¼SW¼ sec. 11, (31-21E), on S. side of Gold Cr. **Elev:** 3,000 ft. **Access:** 4 mi. up Gold Cr. from State Highway No. 16 by road. **Prop:** 1 claim in the Antimony Queen group. **Owner:** H. B. Johnston, Seattle, Wash. (1949). **Ore:** Antimony. **Ore min:** Stibnite, pyrite. **Gangue:** Quartz. **Deposit:** Mineralized shear zone 1 to 2 ft. wide in argillite and conglomerate. About 20 tons of ore on the dump. **Dev:** Trench 20 ft. long. **Ref: 132,** pp. 124-125.

Laeuna
(see Leuena under silver)

Last Chance (24)
(see under silver)

Launa
(see Leuena under silver)

Lawrence
(see Lucky Knock)

Leonora (25)
(see under lead)

Leuena (19)
(see under silver)

Lilman (45)
(see under silver)

Little Chief (46)
(see under silver)

Lone Star (20)
(see under lead)

Lucky Knock (Lawrence) (9)

Loc: SW¼ sec. 19, (38-27E), W. of Whitestone Mtn. **Elev:** 1,550 ft. **Access:** 5 mi. by road from railroad at Tonasket. **Prop:** 6 patented claims: Lucky Knock, White Rock, Frozen Mitt, Dead Horse, Sky Line, Perhaps. **Owner:** E. A. Magill, Seattle, Wash. (1950——). Lucky Knock Mining Co. (1907-1918). Standard Sanitary Manufacturing Co. (1915-1934). Whitestone Mines, Inc. (1941-1950). **Ore:** Antimony. **Ore min:** Stibnite, few grains of sphalerite. **Gangue:** Calcite, quartz. **Deposit:** Irregular "pockets" of stibnite intermittently replacing limestone. **Dev:** 1,000 ft. of drifts, crosscuts, and winzes. **Assays:** 47.83 tons shipped in 1949 av. 55.9% Sb. **Prod:** 1907, 1908, 1915-1917, 1941. 600 tons prior to 1949. 47.83 tons in 1949. 1951. **Ref: 97,** 1907, p. 709; 1918, p. 42. **112,** p. 190. **121,** vol. 7, 8/22, pp. 94-96. **130,** p. 58. **132,** pp. 92-104. **133,** p. 33. **141,** pp. 50-51. **154,** p. 107. **158.**

Mineral Hill (14)
(see under silver)

Minnehaha (15)
(see under silver)

Mountain Boy (40)
(see under lead)

Nevada (26)
(see under silver)

New Deal
(see Antimony Queen)

Olentangy (11)
(see under gold)

Panama (49)
(see under silver)

Par Value (47)
(see under silver)

Peacock (22)
(see under silver)

Plant-Callahan (30)
(see under silver)

Prince

Loc: Riverside area. **Owner:** Montana-Washington Engineering Co. **Ore:** Antimony. **Ref: 158.**

Pyrargyrite
(see Ruby under silver)

Ramore (43)
(see under lead)

Reedy
(see Antimony Queen)

Rich Bar (5)
(see under copper)

Ruby (3)
(see under silver)

Salmon River (16)
(see under silver)

Seven Devils
(see Mineral Hill under silver)

Sidewinder
(see under gold)

Silver King (17)
(see under lead)

Silver Seal
(see Antimony Queen)

Sonny Boy (27)
(see under silver)

Stibnite (32)

Loc: NE¼SE¼ sec. 3, (31-21E), on ridge N. of the old Foggy Dew C.C.C. camp. **Elev:** 2,800 ft. **Access:** Road to the Foggy Dew camp, thence across country on foot. **Owner:** Abandoned (1948). **Ore:** Antimony. **Ore min:** Stibnite. **Deposit:** Shear zone 2 ft. wide in diorite may have been mineralized to a width of 1 ft. by stibnite. No ore in sight. **Dev:** 10-ft. trench. **Ref: 132,** pp. 125-126.

Summit (38)
(see under lead)

Sunrise
(see under silver)

Sunshine Chief
(see Chief Sunshine under silver)

Swayne (2)
(see under copper)

Wasco (41)
(see under silver)

Washington Consolidated
(see Mineral Hill under silver)

Whitestone (12)
(see under gold)

Windfall
(see under silver)

PEND OREILLE COUNTY

Bromide
(see La Sota under silver)

La Sota (3)
(see under silver)

Lena Belle (5)
Loc: SE¼NE¼ sec. 6, (32-45E), near foot of SW. slope of No Name Peak, Newport dist. **Elev:** 3,000 ft. **Access:** Road. **Owner:** C. W. Carter and W. M. Miles, Newport, Wash. (1950). **Ore:** Antimony. **Ore min:** Stibnite. **Deposit:** A deposit of massive stibnite 18 in. thick was exposed for a strike length of about 10 ft. in dolomite. **Ref: 132**, p. 126. **139.**

Maryland
(see Pinnel)

Oriole (2)
(see under zinc)

Pinnel (Maryland) (4)
Loc: NW¼SE¼ sec. 12, (33-44E), on E. bank of N. Fk. of Skookum Cr. **Elev:** 3,200 ft. **Access:** 8½ mi. from Usk on the Skookum Cr. road. **Prop:** 60 acres deeded land. **Owner:** Ed Maryland, Usk, Wash. (1949). Leased by J. W. Pinnel (1942). **Ore:** Antimony. **Ore min:** Stibnite. **Deposit:** Lenses of intermixed quartz and stibnite, ⅛ in. wide and 4 in. in dia. fill fractures in quartzite a few hundred ft. W. of granodiorite body. **Dev:** 480-ft. adit, two open cuts. **Ref: 29**, pp. 70-71. **132**, pp. 126-127. **139**, pp. 52-53. **157.**

Silver Crest
(see La Sota under silver)

Uncas (1)
(see under zinc)

SKAGIT COUNTY

Higgins Mountain
(see Lawrence under copper)

Lawrence (1)
(see under copper)

SNOHOMISH COUNTY

Alleghany
(see Foggy under copper)

Big Four (10)
(see under lead)

Bonanza Queen (7)
(see under copper)

Clara Thompson
(see Jasperson under gold)

Columbia Mountain
Loc: Troublesome Cr. area, 15 mi. from Index. **Access:** Trail. **Prop:** 2 claims. **Ore:** Reportedly antimony. **Ore min:** Said to be tetrahedrite. **Ref: 158.**

Commonwealth
(see Jasperson under gold)

Consolidated
(see under gold)

Eureka (8)
(see under copper)

Everett (9)
(see under copper)

Feldt (1)
(see under silver)

Foggy (14)
(see under copper)

"45" (11)
(see under silver)

Glengarry
(see under silver)

Gold Mountain (3)
(see under copper)

Gray Mare (2)
(see under silver)

Hard Pass (12)
(see under copper)

Jasperson (13)
(see under gold)

McCombs
(see Jasperson under gold)

Magus
(see "45" under silver)

Monitor and Sterling (6)
(see under copper)

Monte Cristo (16)
(see under gold)

Myrtle C (4)
(see under copper)

Mystery
(see Monte Cristo under gold)

New Seattle (5)
(see under silver)

Old Gray Mare
(see Gray Mare under silver)

Penn
(see Foggy under copper)

Perm
(see under gold)

Pride
(see Monte Cristo under gold)

Sterling
(see Monitor and Sterling under copper)

Webster
(see Jasperson under gold)

Whistler (15)
(see under lead)

STEVENS COUNTY

Acme (25)
(see under lead)

Aguila (26)
(see under lead)

Anaconda (8)
(see under lead)

Ark (24)
(see under silver)

Banner
(see Chinto under copper)

Blue Star
(see Eagle under silver)

Boundary Silver Lead
(see Lucile under zinc)

Brooks (47)
(see under silver)

Chewelah Eagle
(see Eagle under silver)

Chinto (30)
(see under copper)

Cleveland (42)
(see under lead)

Columbia River (20)
(see under copper)

Contention
(see Mountain View under silver)

Copper King (7)
(see under lead)

Copper Queen (28)
(see under copper)

Daisy
(see Daisy-Tempest under silver)

Daisy-Tempest (27)
(see under silver)

Deer Trail (43)
(see under silver)

Delmonico
(see Jay Dee under silver)

Dora
(see Acme under lead)

Eagle (32)
(see under silver)

Eagle-Newport
(see Aguila under lead)

Easter Sunday (1)
(see under gold)

Edna (39)
(see under copper)

Enterprise
(see Jay Dee under silver)

Frisco Standard (12)
(see under silver)

Galena Farm (17)
(see under lead)

Gold Bar (19)
(see under gold)

Hartford
(see Krug under copper)

High Grade
(see Jay Dee under silver)

Hoodoo (44)
(see under silver)

Jay Dee (29)
(see under silver)

Jay Gould (33)
(see under silver)

Joe Day (16)
Loc: Sec. 25, (38-39E). **Access:** Near road. **Prop:** Said to consist of several unpatented claims. **Owner:** Joe Day, Colville, Wash. (1941). **Ore:** Antimony. **Ore min:** Stibnite. **Ref: 30,** p. 86.

Kazian
Loc: Stevens County. **Owner:** John Kazian, Seattle, Wash. (1945). **Ore:** Antimony. **Ore min:** Stibnite. **Gangue:** Quartz, calcite. **Ref: 158.**

Kemp Komar
(see Loon Lake Copper under copper)

Keough (13)
(see under lead)

Key West
(see Loon Lake Copper under copper)

King
(see Edna under copper)

Krug (36)
(see under copper)

Liberty Copper (37)
(see under copper)

Little Frank (45)
(see under lead)

Longshot (22)
(see under lead)

Loon Lake Copper (40)
(see under copper)

Lucile (9)
(see under zinc)

Maple Leaf
(see Melrose under silver)

Melrose (6)
(see under silver)

Middleport (23)
(see under zinc)

Mountain View (4)
(see under lead)

Mullen (34)
(see under lead)

Myeerah (10)
(see under lead)

Nevada (38)
(see under lead)

Newland
(see Longshot under lead)

Newport
(see Aguila under lead)

Orazada (48)
(see under silver)

Owen
(see Lucile under zinc)

Paragon
(see Melrose under silver)

Pioneer
(see Longshot under lead)

Pomeroy (2)
(see under zinc)

Providence (3)
(see under lead)

Providence (Deer Trail)
(see Deer Trail under silver)

Redwood
(see Eagle under silver)

Rinchaw
(see Middleport under zinc)

Robena
(see Young America under zinc)

Royal Gold
(see Hubbard under lead)

Santa Rita
(see Cleveland under lead)

Saturday Night-Sunday Morning (46)
(see under lead)

Schoneberg
(see Schrenberg)

Schrenberg (Schoneberg) (35)
Loc: SE¼SW¼ sec. 18, (32-41E), 1 mi. SE. of Chewelah. **Access:** Road within ¼ mi. of the deposit. **Prop:** 20 acres of deeded land. **Owner:** J. J. Schrenberg, Chewelah, Wash. (1900-1949). Leased to R. T. Bennett, Orland, Calif. (1943). **Ore:** Antimony. **Ore min:** Stibnite, chalcopyrite, pyrite. **Gangue:** Quartz, calcite. **Deposit:** Stibnite occurs as very small lenses in dolomite along the footwall of a 3-ft. quartz vein. **Dev:** 165-ft. shaft, 20-ft. shaft. **Ref: 132,** p. 144. **157.**

Silver Mountain
(see Daisy-Tempest under silver)

Silver Queen
(see Ark under silver)

Sugar Loaf
(see Vanasse under silver)

Sunday Morning
(see Saturday Night-Sunday Morning under lead)

Sunset (5)
(see under lead)

Tempest
(see Daisy-Tempest under silver)

Tile Creek (15)
Loc: SW¼ sec. 7, (38-39E), on E. Bank of Ryan Cr. N. of Swede Pass. **Elev:** 1,800 ft., about 500 ft. above Columbia R. **Access:** Swede Pass road. **Ore:** Antimony. **Ore min:** Stibnite, scheelite, stibiconite, cervantite. **Deposit:** Quartz lens as much as 2 ft. thick along contact of limy argillite with a sill. Lens of ore now mined out. **Dev:** 35-ft. adit. **Ref: 132,** pp. 144-145.

United Copper (31)
(see under copper)

United Silver Copper
(see United Copper under copper)

United Treasure (11)
(see under silver)

Vanasse (21)
(see under silver)

Venus
(see Deer Trail under silver)

Victory
(see Vanasse under silver)

Wall Street (14)
(see under copper)

Wells Fargo (41)
Loc: NW¼NE¼ sec. 36, (31-38E), on E. slope of Huckleberry Range near summit, Deer Trail dist. **Elev:** 3,800 to 3,950 ft. **Access:** Road from Springdale. **Prop:** 80 acres State land. **Owner:** Leased by C. R. Carr, J. M. Carr, and F. B. Carr (1946-1949). Wells-Fargo Mining Co. (1897-1920). **Ore:** Antimony, silver, gold, lead, zinc. **Ore min:** Stibnite, pyrite, jamesonite. **Gangue:** Quartz, barite. **Deposit:** 3- to 5-ft. quartz vein in argillite and dolomite essentially parallel to laminations of the country rock. Jamesonite occurs disseminated in the vein. **Dev:** 2 crosscut adits and a shaft. One adit 125 ft. long, the other 180 ft. **Assays:** Ore shipped av. 7% Sb. A sample across 3 in. of highest grade part of vein at open pit showed 0.02 oz. Au, 2.0 oz. Ag, 13.4% Pb, 0.05% Zn, 6.0% Sb. A grab sample from vein in upper adit showed 0.03 oz. Au, 5.2 oz. Ag, 18.9% Pb, 2.0% Zn, 14.1% Sb. **Prod:** Small shipment of antimony ore in 1937. **Ref: 30,** p. 75. **130,** pp. 58-59. **132,** pp. 146-148. **141,** p. 51. **157. 158. 164,** pp. 212-213.

Young America (18)
(see under zinc)

WHATCOM COUNTY

Gold Hill (1)
(see under silver)

Northern Cascade
(see Gold Hill under silver)

Peterson
(see Gold Hill under silver)

YAKIMA COUNTY

Richmond (1)
(see under lead)

ARSENIC

Properties—Arsenic has been variously classified as a metal, a metal-like solid, a semi-metal, and a nonmetal, but in its appearance and in some of its other physical and chemical properties it has the qualities of a metal. It is a steel-gray, very brittle, crystalline solid having a hardness of 3.5 and metallic luster. Some other properties are shown in the table on page 12. It sublimes easily to a yellowish vapor which has a garlic-like odor, and it catches fire at about 180° C. It displays two valences, 3 and 5, in its compounds with other elements. The free element is not considered poisonous, but all its soluble inorganic compounds are violent poisons.

Uses—Arsenic finds its greatest use in the form of its poisonous compounds, such as the calcium, lead, and sodium arsenates, lead arsenite, and Paris green, for insecticides and weed killers. Arsenic is used in making glass, enamels, wood preservatives, drugs, dyes, and as alloys with lead and copper. In copper it increases the corrosion resistance and raises the annealing temperature, and for shot metal it is added to lead in amounts up to 1 percent to harden and improve the sphericity of the shot.

Production—Little arsenic is produced in the metal form; most of it is made in the form of white oxide, As_2O_3. Washington has the distinction of being the first state in this country to produce white arsenic on a commercial scale. Equipment to recover white arsenic at a smelter in Everett was built in 1901, and for several years it was the only producer in the United States. In its first 3 years of operation it produced 2,052 tons of white arsenic, valued at $135,871, as a byproduct of smelting gold ores, principally from the Monte Cristo district in Snohomish County. The copper smelter at Tacoma began recovering white arsenic in 1907, and it is reported to have produced 3,000 tons in 1920. This plant has produced arsenic intermittently to the present time, and in 1950 it was one of only five producers in this country. Domestic white arsenic is produced principally as a byproduct in smelting ores of copper and lead, and the amount of production depends primarily on the market demand rather than on existing plant capacity. The availability of relatively cheap byproduct arsenic makes it improbable that arsenic mining, as such, will ever be profitable in Washington in normal times, but in the past, two small plants operated briefly on straight arsenic ores. In 1906 a plant near Mineral, Lewis County, used realgar ore, and the same type of ore was treated in 1920 in a 15-ton mill at Reiter, Snohomish County.

Prices—The price history of arsenic is markedly different from that of the other metals in that the price has changed relatively little over a long period of years. Although the price for white arsenic rose from 8½ cents per pound in August 1922 to 15½ cents in December of that year, the price was 5 cents in 1925 and since then has been relatively stable with very little rise. In fact, the 10-year average from 1941 through 1950 was 4.8 cents, only 0.8 cents higher than the 4.0-cent average for the 10 years from 1925 through 1934. Although the price has been fairly stable, the market demand has varied greatly from year to year, depending upon the demand for arsenical insecticides.

Ore minerals—Native arsenic is fairly common but has been reported in Washington only in the vicinity of Goat Lake in the Monte Cristo district, Snohomish County. The most common arsenic minerals are arsenopyrite, FeAsS, containing 46.0 percent arsenic, and the sulfides, realgar, AsS, containing 70.1 percent arsenic, and orpiment, As_2S_3, containing 61.0 percent arsenic. These are widely distributed throughout the mineralized districts of the state. Perhaps the district best known for its arsenical ores is the Monte Cristo camp in Snohomish County, where arsenopyrite was mined for its gold and silver content. Other, less common arsenic minerals are arsenolite, As_2O_3; tennantite, $3Cu_2S{\cdot}As_2S_5$; proustite, $3Ag_2S{\cdot}As_2S_3$; the arsenides, löllingite, $FeAs_2$; smaltite, $CoAs_3$; cholanthite, $NiAs_3$; niccolite, NiAs; and many rare sulfarsenides of copper, silver, and lead.

Geology—Arsenopyrite is found in a wide variety of occurrences, as with tin and tungsten in pneumatolitic deposits; in quartz veins with gold, silver, galena, sphalerite, pyrite, chalcopyrite, tetrahedrite, calcite, siderite, and many other minerals; with cobalt and nickel ores; in contact-metamorphic deposits; in pegmatites; and disseminated in crystalline rocks, as schist, gneiss, limestone, and serpentine; but it usually favors deep-zone conditions of origin. On the other hand, realgar, orpiment, and arsenolite are usually found at shallow depths. Arsenolite is always a secondary mineral, but realgar and orpiment may be either primary or secondary.

OCCURRENCES

The map showing the numbered arsenic occurrences is plate 2, on page 9 in volume 2.

CHELAN COUNTY

Alta Vista (13)
(see under gold)

Bismarck (7)
(see under zinc)

Black Jack (20)
(see under gold)

Black and White (21)
(see under gold)

Blewett
(see Black Jack, also Peshastin under gold)

Blind Lead
(see under gold)

Blue Jay (6)
(see under copper)

Clagstone (2)
(see under lead)

Culver (14)
(see under gold)

Diamond Dick
(see Black and White under gold)

Doubtful (3)
(see under lead)

Ellen
(see Van Epps under antimony)

Esmeralda
(see under gold)

King Solomon (5)
(see under copper)

King Solomon (Van Epps)
(see Van Epps under antimony)

La Rica
(see Black Jack, also Peshastin under gold)

Moscow (4)
(see under copper)

North Star (15)
(see under gold)

Olympia (16)
(see under gold)

Orphan Boy (8)
(see under silver)

Peshastin (17)
(see under gold)

Phipps (18)
(see under gold)

Pole Pick No. 2
(see Alta Vista under gold)

Quien Sabe (1)
(see under lead)

Red Cap (9)
(see under gold)

Red Hill (10)
(see under gold)

Red Mountain (11)
(see under copper)

Royal
(see Red Mountain under copper)

Sandell (19)
(see under gold)

Snook and Ellen
(see Van Epps under antimony)

Van Epps (12)
(see under antimony)

FERRY COUNTY

Apex
(see Big Chief under lead)

Big Chief (12)
(see under lead)

Blue Horse (3)
(see under silver)

Blue Jacket (4)
(see under silver)

Chief
(see Big Chief under lead)

Colorado (15)
(see under lead)

Gwin (7)
(see under silver)

Hall Creek
(see Gwin under silver)

Juliet (9)
(see under lead)

Juno (5)
(see under silver)

Kentucky Belle (2)
(see under lead)

Little Tom
(see Juliet under lead)

Meteor (10)
(see under silver)

New York (11)
(see under lead)

Pin Money (1)
(see under gold)

Robert E. Lee (13)
(see under antimony)

Rover Bonanza (16)
(see under silver)

Silver Tip (6)
(see under silver)

Stray Dog (8)
(see under silver)

U. S. (14)
(see under lead)

KING COUNTY

Aces Up (10)
(see under silver)

Apex (2)
(see under gold)

Bear Basin (12)
(see under silver)

Bergeson (4)
(see under gold)

Black Diamond (20)

Loc: 1,498 ft. W. and 320 ft. S. of NE. cor. sec. 14, (21-6E), about ½ mi. NE. of Black Diamond. **Elev:** About 700 ft. at collar. **Ore:** Arsenic. **Ore min:** Realgar. **Deposit:** Realgar occurs as disseminated spots and along joint planes in massive arkosic sandstone at depth of 3,274 to 3,284 ft. in oil test well drilled by the Shell Oil Co. in 1947. **Ref: 158.**

Bondholders Syndicate
(see Apex under gold)

Cleopatra (11)
(see under silver)

Coney Basin (7)
(see under gold)

Copper Plate
(see Seattle-Cascade under silver)

Damon and Pythias (1)
(see under gold)

Dawson (8)
(see under lead)

Dutch Miller (13)
(see under copper)

Extra (5)
(see under gold)

Fathers Day (18)
(see under copper)

Franklin
(see Red Crystal)

Goat Mountain (17)
(see under lead)

Green River (21)
Loc: Center sec. 17, (21-7E), in cliff along Green R. **Access:** 2 mi. from railroad. **Owner:** Northern Pacific Railway Co. (1944). **Ore:** Arsenic. **Ore min:** Realgar, orpiment. **Deposit:** Small pods, lenses, and lean disseminations in shear zone in sandstone exposed for 50-ft. length, 4- to 10-ft. width, 40- to 50-ft. depth. **Dev:** 75-ft. adit. **Assays:** 4 samples representing width of 29 ft. gave av. of 1.64% As. **Ref: 111,** p. 5. **157.**

Last Chance (3)
(see under gold)

Lennox (16)
(see under gold)

Mona
(see Mono under copper)

Mono (6)
(see under copper)

Monte Carlo (14)
(see under gold)

Mount Phelps (15)
(see under zinc)

Normandie
(see Bergeson under gold)

Pythias
(see Damon and Pythias under gold)

Red Crystal (Franklin) (19)
Loc: Sec. 8, (21-7E), at river level on W. bank of Green R. **Elev:** 500 ft. **Access:** 1 mi. N. of Franklin. **Ore:** Arsenic. **Ore min:** Realgar, orpiment. **Deposit:** Ore minerals occur in a hydrothermally altered dike cutting across sandstone, shale, and coal. Ore appears to be concentrated near the coal bed. **Dev:** 10-ft. adit. **Ref: 44,** p. 46. **130,** p. 60.

Seattle-Cascade (9)
(see under silver)

Silver Dollar and Copper Plate
(see Seattle-Cascade under silver)

Sockless Jerry
(see Last Chance under gold)

Triple S
(see Seattle-Cascade under silver)

KITSAP COUNTY

Chico (1)
(see under tin)

Cook-Kitchen
(see Chico under tin)

Kitchen
(see Chico under tin)

KITTITAS COUNTY

American Eagle
(see under gold)

Aurora (1)
(see under gold)

Bob Canson (4)
(see under copper)

Boss
(see under gold)

Edna R. (2)
(see under gold)

Little Kachess Lake (5)
(see under copper)

Lynch
(see Aurora under gold)

Maud O. (3)
(see under gold)

Paramount
(see Aurora under gold)

LEWIS COUNTY

Eagle Peak (2)
(see under copper)

Mineral Creek (1)
(see under zinc)

Paradise (3)
(see under copper)

OKANOGAN COUNTY

Abernathy (24)
(see under copper)

Antimony Gold
(see Abernathy under copper)

Antimony Queen (30)
(see under antimony)

Bellevue (5)
(see under gold)

Black Rock (29A)
Loc: NW¼NE¼ sec. 4, (31-21E), on N. side of Gold Cr. **Access:** Road to within ¼ mi. of property. **Owner:** Wade Smith (1953). **Ore:** Arsenic, gold. **Ore min:** Arsenopyrite, sphalerite. **Deposit:** Quartz vein 1 to 6 in. thick in a 6-ft. crushed zone with graywacke in hanging wall and volcanic rock in footwall. **Dev:** 10-ft. adit. **Ref: 158.**

Bolinger (32)
(see under gold)

Carlquist (9)
(see under antimony)

Chesaw (12)
(see under gold)

Copper World (7)
(see under copper)

Copper World Extension (8)
(see under copper)

Crown Point
(see Imperial under gold)

Crystal Butte (13)
(see under gold)

Dixie Queen
(see Antimony Queen under antimony)

Friday (33)
(see under gold)

Gold Key (22)
(see under gold)

Golden Triangle
(see under gold)

Golden Zone (1)
(see under gold)

Heath (27)
(see under lead)

Homestake (16)
(see under lead)

Horn Silver (4)
(see under silver)

Imperial (19)
(see under gold)

Iron Cap and Snow Cap (25)
(see under gold)

Iron Mask
(see Copper World Extension under copper)

Mazama Pride (23)
(see under gold)

Mid Range (26)
(see under gold)

Montana (20)
(see under copper)

Mother Lode (14)
(see under gold)

New Deal
(see Antimony Queen under antimony)

Olentangy (10)
(see under gold)

Pyrargyrite
(see Ruby under silver)

Rainbow (6)
(see under gold)

Rattlesnake (28)
(see under gold)

Reco (11)
(see under gold)

Red Shirt (29)
(see under gold)

Reedy
(see Antimony Queen under antimony)

Rosalind (21)
(see under gold)

Ruby (2)
(see under silver)

Saint (3)
(see under gold)

Salmon River (17)
(see under silver)

Second Prize
(see under gold)

Shelby
(see under silver)

Sherman (18)
(see under lead)

Silver Ledge (31)
(see under gold)

Silver Seal
(see Antimony Queen under antimony)

Silver Star
(see under silver)

Silver Tip
(see Starr under molybdenum)

Snow Cap
(see Iron Cap and Snow Cap under gold)

Standard
(see Sherman under lead)

Starr (15)
(see under molybdenum)

Tom Hal
(see Friday under gold)

PEND OREILLE COUNTY

Alger and McCullough (2)
(see under copper)

Bead Lake (3)
(see under lead)

Blue Jim (1)
(see under silver)

Conquest
(see Kootenai Conquest under lead)

Kootenai Conquest (4)
(see under lead)

McCullough
(see Alger and McCullough under copper)

Snowbird and Stanley (5)
(see under lead)

Stanley
(see Snowbird and Stanley under lead)

West
(see Blue Jim under silver)

PIERCE COUNTY

Clipper (1)
(see under copper)

Mothers Day
(see Clipper under copper)

Silver Creek (2)
(see under gold)

SKAGIT COUNTY

Alta (6)
(see under lead)

Alverson (1)
(see under nickel)

Boston (7)
(see under lead)

Cerrico
(see under lead)

Chicago (8)
(see under lead)

Clear Lake (2)
Loc: Near Clear Lk. **Ore:** Arsenic. **Ore min:** Realgar. **Ref:** 141, pp. 54-55.

Cultus Mountain (4)
(see under nickel)

Higgins Mountain
(see Lawrence under copper)

Lawrence (5)
(see under copper)

Nookachamps Creek (3)
Loc: Near S. line sec. 22, (34-5E), on the upper part of Nookachamps Cr. **Ore:** Arsenic. **Ore min:** Realgar. **Deposit:** Realgar float found as boulders in the stream is not much rounded and may be near the source. **Ref: 158.**

SKAMANIA COUNTY

Commonwealth (1)
(see under copper)

Perry (2)
(see under gold)

SNOHOMISH COUNTY

Ala-Dickson (27)
(see under copper)

Alleghany
(see Foggy under copper)

American Arsenic
(see Reiter)

Argonaut and Typo (49)
(see under gold)

Ben Lomond
(see Rainy under gold)

Big Four (24)
(see under lead)

Blue Rock (36)
(see under copper)

Bonanza
(see Mineral Center under gold)

Bonanza Queen (10)
(see under copper)

Border Queen (31)
(see under copper)

Boston
(see Butte and Boston)

Bullet (8)
(see under copper)

Butte and Boston
Loc: Index dist. **Owner:** Cascade Arsenic Mining Co. (1902). **Ore:** Arsenic. **Ref: 105,** 9/02, p. 138.

Calumet (32)
(see under gold)

Cassidy (50)
(see under gold)

Chickamun
(see Forest-Chickamun under copper)

Clara Thompson
(see Jasperson under gold)

Cleveland (13)
(see under copper)

Commonwealth
(see Jasperson under gold)

Consolidated
(see under gold)

Copper Chief (60)
(see under copper)

Copper Independent (14)
(see under gold)

Daisy (57)
(see under gold)

Dry Creek
(see under gold)

Eclipse (15)
(see under gold)

Edison (42)
(see under gold)

Eldred (33)
(see under copper)

Engdahl (61)
(see under zinc)

Feldt (1)
(see under silver)

Foggy (40)
(see under copper)

Forest-Chickamun (5)
(see under copper)

"48-55" (29)
(see under copper)

"45" (23)
(see under silver)

Garnet
(see "48-55" under copper)

Glory of the Mountain (35)
(see under gold)

Gold Eagle (43)
(see under gold)

Golden Chord
(see Justice under gold)

Granite and Maud (16)
(see under gold)

Great Scott (56)
(see under gold)

Hicks
(see Sultan King under copper)

Hustler (34)
(see under copper)

Imperial (17)
(see under copper)

Independent
(see Copper Independent under gold)

Index Gold Mines, Inc. (68)
(see under gold)

Iron Clad (69)
(see under gold)

Jasperson (62)
(see under gold)

Jim Dandy (63)
(see under gold)

Justice (51)
(see under gold)

Lida (44)
(see under copper)

Lily James (11)
(see under gold)

Lily of the West (37)
(see under gold)

Little Chief (28)
(see under copper)

Louise
(see Mineral Center under gold)

Lucky Strike (9)
Loc: NE¼ sec. 24, (30-9E). **Access:** On edge of the highway ½ mi. W. of Silverton. **Prop:** 1 claim. **Owner:** V. D. McCrory, Erick Shedin, and James Bossart (1942). **Ore:** Arsenic. **Ore min:** Pyrite, arsenical pyrrhotite. **Deposit:** 12-in. vein of heavy sulfide ore pinches out in 20 ft. of drifting. **Dev:** 80-ft. adit. **Ref: 158.**

Lulu (18)
(see under gold)

McCombs
(see Jasperson under gold)

Mackinaw (58)
(see under copper)

Magus
(see "45" under silver)

Martin Engdahl (64)
(see under lead)

Maud
(see Granite and Maud under gold)

Milwaukee (25)
(see under zinc)

Mineral Center (45)
(see under gold)

Mineral Mountain (46)
Loc: NW¼ sec. 31, (29-11E), Silver Cr. dist. **Ore:** Arsenic. **Ore min:** Arsenopyrite. **Ref: 14,** p. 35.

Monte Cristo (52)
(see under gold)

Mountain Cedar (30)
(see under copper)

Mystery (Monte Cristo, Pride)
(see Monte Cristo under gold)

Mystery (Mountain Cedar, Paystreak)
(see Mountain Cedar under copper)

National (47)
(see under copper)

Nemo (12)
(see under gold)

New York (19)
(see under copper)

North Star
(see Sunrise under gold)

O and B (41)
(see under copper)

Oldfield
(see Sunrise under gold)

Ore Recoveries (20)
(see under copper)

Paystreak
(see Mountain Cedar under copper)

Peabody (53)
(see under gold)

Pelican (3)
(see under gold)

Penn
(see Foggy under copper)

Perm
(see under gold)

Philo (54)
(see under copper)

Pride
(see Monte Cristo under gold)

Queen Anne (4)
(see under gold)

Rainy (55)
(see under gold)

Reiter (American Arsenic) (71)
Loc: Sec. 1, (27-9E) and sec. 6, (27-10E), near the headwaters of Hogarty Cr. **Elev:** 2,400 ft. **Access:** Trail up the N. side of Hogarty Cr. **Owner:** Julius Haun, Gold Bar, Wash. American Arsenic Mining Co. (1921-1923). Western Copper Mining Co. (1924-1926). **Ore:** Arsenic. **Ore min:** Realgar, orpiment, arsenolite. **Deposit:** Ore occurs as 2- to 12-in. fracture fillings in granodiorite. Several smaller veinlets. **Dev:** 150-ft. adit, another short adit, and several open cuts. **Assays:** Owners est. large body of ore av. 20% arsenic sulfides. **Prod:** 22 tons of red arsenic in 1922-1923. **Ref: 14,** pp. 15-16. **97,** 1922, p. 64. **98,** 1925, p. 1838; 1926, p. 1600. **129,** pp. 291-293. **130,** pp. 59-60. **141,** pp. 22, 54, 55.

Ruby King (65)
(see under gold)

Sam Strom (6)
(see under copper)

Silver Horseshoe (26)
(see under silver)

Silver Slipper (66)
(see under gold)

Sultan King (59)
(see under copper)

Sultan Queen
(see Sultan King under copper)

Sunrise (2)
(see under gold)

Sunset (38)
(see under gold)

Texas (70)
(see under gold)

Typo
(see Argonaut and Typo under gold)

Union (39)
(see under gold)

Vesper Peak
(see "48-55" under copper)

Virginia (21)
(see under copper)

Washington-Iowa
(see Mineral Center under gold)

Webster
(see Jasperson under gold)

Weden Creek
(see Mackinaw under copper)

Westland (67)
(see under copper)

White Gander (7)
(see under copper)

Wild Rose (48)
(see under copper)

Winter Coon (22)
(see under gold)

STEVENS COUNTY

Acme (4)
(see under lead)

Banner
(see Chinto under copper)

Centennial (2)
(see under copper)

Chewelah Consolidated (6)
(see under lead)

Chinto (7)
(see under copper)

Chloride (13)
(see under lead)

Cleveland (12)
(see under lead)

Daisy
(see Daisy-Tempest under silver)

Daisy-Tempest (5)
(see under silver)

Dora
(see Acme under lead)

Edna (11)
(see under copper)

Germania (15)
(see under tungsten)

Gold Bar (3)
(see under gold)

Juno-Echo (9)
(see under copper)

King
(see Edna under copper)

Orazada (16)
(see under silver)

Santa Rita
(see Cleveland under lead)

Silver Mountain
(see Daisy-Tempest under silver)

Tempest
(see Daisy-Tempest under silver)

Togo (14)
(see under copper)

United Copper (8)
(see under copper)

United Silver Copper
(see United Copper under copper)

Western Molybdenum
(see Juno-Echo under copper)

White Horse (1)
(see under copper)

Windfall (10)
(see under copper)

WHATCOM COUNTY

Allen Basin (4)
(see under gold)

Chancellor (2)
(see under gold)

Great Excelsior (1)
(see under gold)

Indiana
(see Chancellor under gold)

Lincoln
(see Great Excelsior under gold)

Mammoth (3)
(see under gold)

President
(see Great Excelsior under gold)

Quinn
Loc: Whatcom County (?). **Owner:** Ed Quinn, Bellingham, Wash. (1942). **Ore:** Arsenic. **Ore min:** Realgar, orpiment. **Gangue:** Quartz. **Ref: 158.**

Tacoma (5)
(see under gold)

YAKIMA COUNTY

Bird (4)
(see under tungsten)

Chinook (1)
(see under copper)

Copper Mining Co. (5)
(see under copper)

Garibaldi (6)
(see under tungsten)

Keystone (3)
(see under copper)

New Find (7)
(see under copper)

Richmond (2)
(see under lead)

BARIUM

Properties—Barium is a soft silver-white metal that is like lead in appearance. It belongs to the alkaline earth group and resembles calcium chemically. Although the metal is not especially heavy, many of its compounds have high density, and many of their uses depend upon this property. The pure metal is unstable and is the most active of the alkaline earth metals except radium. It reacts vigorously with water to produce hydrogen and barium hydroxide. All soluble barium salts are very poisonous. They give a green color to the flame when placed in a fire. Other properties are given in the table on page 12.

Uses—The metal has few uses, but its compounds have several important uses, which are mentioned under barite in Part I of this report. A thin film of barium is used to lubricate the rotor operating at high speed in a vacuum in an X-ray tube, where ordinary lubricants fail. A high-nickel alloy is used in spark plugs, and alloys with lead have been made, but at the present time the only important use for barium metal is as an alloy with magnesium and aluminum as a "getter" in electronic tubes. (A "getter" is a volatile metal introduced into a vacuum tube for removing traces of undesirable gases.) A commonly used "getter" alloy contains one part barium, one part aluminum, and two of magnesium.

Production—In 1950 there were only two reported producers of barium in this country; their total output amounted to several thousand pounds annually. Barite is produced in large quantities in the United States, and small amounts have been mined in Washington in the past, but all but an insignificant portion of this production is for industrial mineral uses rather than as an ore of barium.

Prices—The price of the metal in 1932 was $7.50 to $10.00 per pound, and in 1943 it sold for from $5.00 to $8.00 per pound. In 1950 one producer quoted a price of $6.00 per pound in 1,000-pound lots. Early in 1954 the price of barium metal in rod form was $13.50 per pound in 5- to 10-pound lots.

Ore minerals—The principal ore mineral is the sulfate, barite, $BaSO_4$, containing 58.8 percent barium; but the carbonate, witherite, $BaCO_3$, containing 69.7 percent barium, is not uncommon. Barium is widely distributed as a minor constituent of silicate minerals throughout the igneous rocks.

Geology—Barite occurs as pods, large veins, and beds in sedimentary rocks and as cementing material in sandstone. It is a common gangue mineral in ore deposits.

Occurrences

The occurrences of barite, the principal ore mineral of barium, are listed in Part I of this report.

BERYLLIUM

Properties—Beryllium, also called glucinum, is a steel-gray to silver-white nonductile metal which is brittle at room temperatures. It is similar to magnesium and aluminum in appearance and chemical composition. It weighs only about two-thirds as much as aluminum but is much harder (it will scratch glass but not quartz), has a much higher melting point, is more corrosion resistant, and is four times as elastic as aluminum and almost as elastic as steel. It is capable of taking a high polish. An interesting property is that of transmitting sound at a very high velocity, about 2.5 times that of steel, which apparently has the next highest sound-transmission velocity. The metal has a high melting point, but it distills rapidly at a temperature only slightly greater than its melting point. Other properties are given in the table on page 12.

Uses—Military uses during World War II accounted for approximately 99 percent of domestic consumption, but peacetime uses are increasing. The pure metal is used in neutron generators and for windows in X-ray tubes. The metal and its compounds are of major interest in the atomic-energy program for its moderating effect upon the fast neutrons emitted by the fission of U-235 and plutonium, and probably for other undisclosed applications. Beryllium oxide is used in ceramics such as spark plugs and is receiving much attention in the field of cermets, combined metals and ceramics, for such superduty refractory applications as jet engines and gas turbines. Beryllium compounds are used in fluorescent screens and lights, but since mid-1949 this use has declined sharply due to the use of substitutes. The high velocity of sound in pure beryllium metal may bring applications in the field of acoustics. The major use for the metal is in alloys with iron, aluminum, magnesium, zinc, nickel, and copper, but especially with copper, where it develops properties somewhat analogous to those imparted to steel by carbon. Addition of up to a few percent of beryllium to copper produces a series of alloys that are heat treatable, high strength, highly conductive, corrosion resistant, fatigue resistant, and nonsparking. These alloys have many exacting uses in the manufacture of electrical and other instruments and equipment.

Production—A large part of this country's beryllium supply is imported, and the demand may be expected to increase in the future, so the pressure for discovery of new domestic supplies probably will increase. The only production to date in Washington was a few hundred